Lat 40.97259 Lon -121.64159

Forest Health Protection
Pacific Southwest Region
Northeastern California Shared Service Area

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To: District Ranger, Hat Creek Ranger District, Lassen National Forest

Subject: Evaluation of stand conditions within the Crossroads Project (FHP Report NE17-04)

Summary

At the request of Bobette Jones, Ecologist, Hat Creek Ranger District, Danny Cluck, Forest Health Protection (FHP) Entomologist conducted a field evaluation of the Crossroads project on March 23, 2017. The objective of this visit was to evaluate the current forest health conditions within the proposed project area, discuss what influence these conditions would have on stand management objectives, discuss the use of the 2014 Farm Bill categorical exclusion and provide recommendations as appropriate. Bobette Jones accompanied me to the field.

Key findings:

- Overstocking is putting many stands at risk to high levels of bark beetle-caused tree mortality during periods of drought.
- Mixed conifer stands have become denser with a higher proportion of white fir and Douglas-fir in the absence of fire.
- Many stands have experienced high levels of ponderosa pine and Douglas-fir mortality during current and recent droughts.
- Ponderosa pine stands within portions of the project area have a history of infestations of black pineleaf scale, which have predisposed trees to bark beetle attacks.
- High fuels loads, consisting of an abundance of dead-down trees and a dense understory of live trees have put some stands at risk to stand replacing wildfire.
- Thinning is highly recommended throughout the Crossroads project area to reduce stocking of all tree species.
- Opportunities also exist to enhance growing conditions for older Oregon white oaks through radial thinning.

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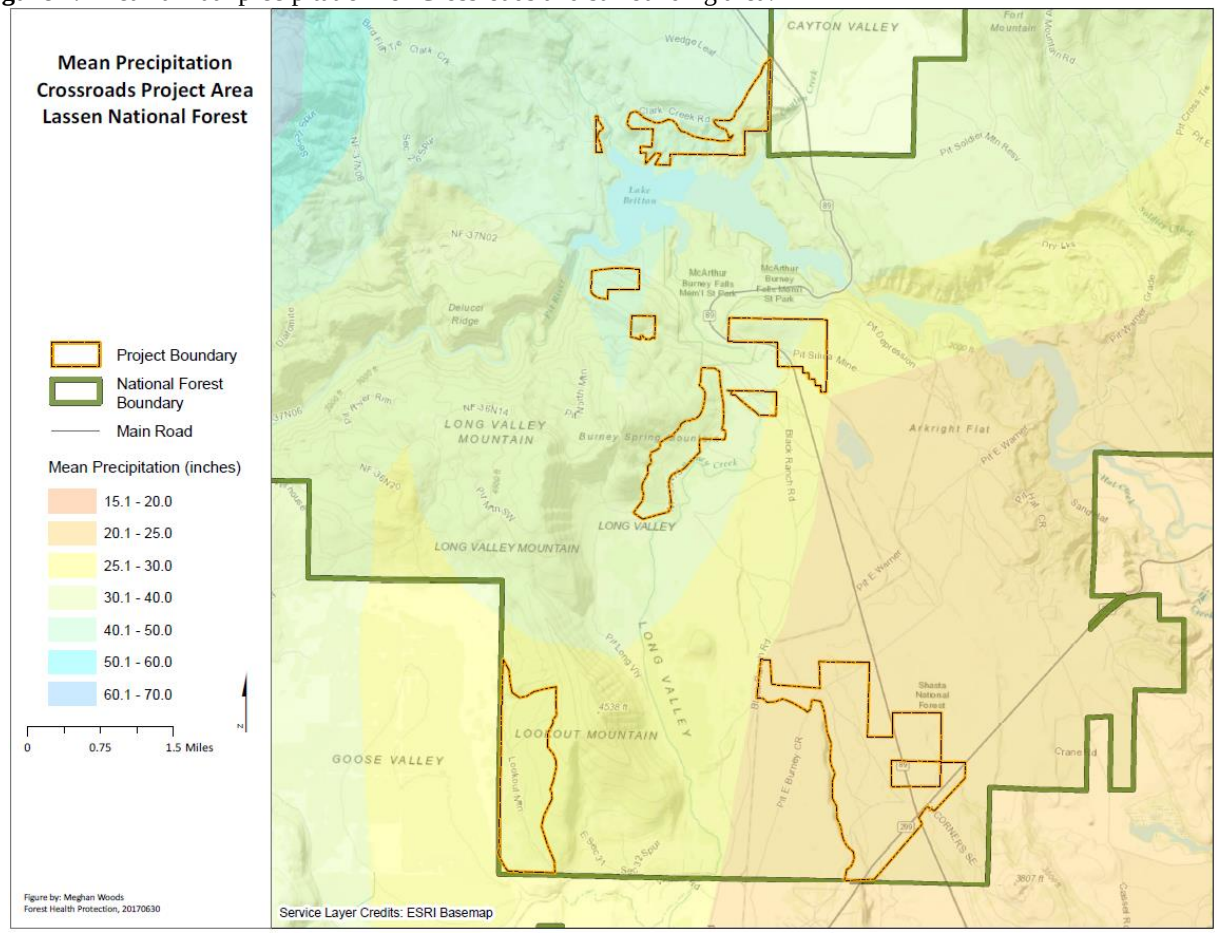
Description of the project area

The Crossroads project is located approximately 2 miles northeast of Burney, CA at elevations ranging between 3,000 and 3,750 feet (40.972594N and 121.641585W). Annual precipitation ranges between 20 and 40 inches (Figure 1). Ponderosa pine (*Pinus ponderosa*) stands dominate the drier southeastern part of the project mixed with Oregon white oak (*Quercus garryana*) and western juniper (*Juniperus occidentalis*). Mixed conifer is found in the wetter northwest portion of the project area, consisting of ponderosa pine, Douglas-fir (*Psuedotsuga menziesii*), white fir (*Abies concolor*), sugar pine (*Pinus lambertiana*), incense cedar (*Calocedrus decurrens*) and Oregon white oak.

Figure 1. Mean annual precipitation for Crossroads and surrounding area.



Project objectives

The Crossroads project proposes to reduce the risk of insect and disease-caused tree mortality through mechanical and hand thinning, mastication of brush and prescribed burning. Ponderosa pine stands will be thinned to approximately 60 - 80 sq. ft./acre of basal area emphasizing stand variability and large Oregon white oak release. Mixed conifer stands will retain relatively higher stocking based on local site conditions but emphasize the reduction of Douglas-fir and white fir. The residual stands will be more open, increasing the amount of available soil moisture and sunlight for individual trees, and contain fewer shade intolerant species. This project will increase the resiliency of treated stands to bark beetles and black pineleaf scale. The project will be accomplished using the 2014 Farm Bill categorical exclusion.

Forest insect and disease conditions

Agents/hosts observed during this site visit:

- Western pine beetle (*Dendroctonus brevicomis*)-caused mortality of ponderosa pine
- Top-killing of ponderosa pine by (*Ips* spp.)
- Fir engraver beetle (*Scolytus ventralis*)-caused mortality of white fir
- Flatheaded fir borer (*Phaenops drummondi*)-caused mortality of Douglas-fir
- California flatheaded borer (*Phaenops californica*)-caused mortality of ponderosa pine
- Top-killing and small tree mortality of Douglas-fir caused by Douglas-fir engraver beetle (*Scolytus unispinosus*)

Stand conditions and mortality related to recent and future climate trends

Many of the forested areas in the Crossroads area are in an overstocked condition and are currently experiencing an elevated level of tree mortality caused by bark and woodboring beetles (Table 1 and Figures 2 - 5). This mortality combined with high stand density has resulted in heavy fuel loading in some areas and a corresponding increase in fire danger.

Table 1. Acres with mortality, estimated dead trees per acre and estimated total # of dead trees from R5 Aerial Detection Surveys and Palmer Hydrologic Drought Index (PHDI) (average of CA Divisions 2 and 3[1]) by water year (Oct-Sept) within the Crossroads units.

Year	Acres	Dead Trees/Acre	Total # of Dead Trees	PHDI[2]
2016	2,175	15.4	33,487	-1.28
2015	250	2.5	626	-3.34
2014	182	2.9	520	-3.56
2013	221	3.5	775	-2.16
2012	1	1.4	2	-0.59
2011	<1	1.4	1	2.78
2010	92	3.3	307	-0.14
2009	74	2.1	154	-2.98
2008	<1	3.2	1	-3.16
2007	<1	12.9	4	-3.17

[1] California Divisions 2 and 3 encompass most of northeastern California. Crossroads is close to the border between these two zones.

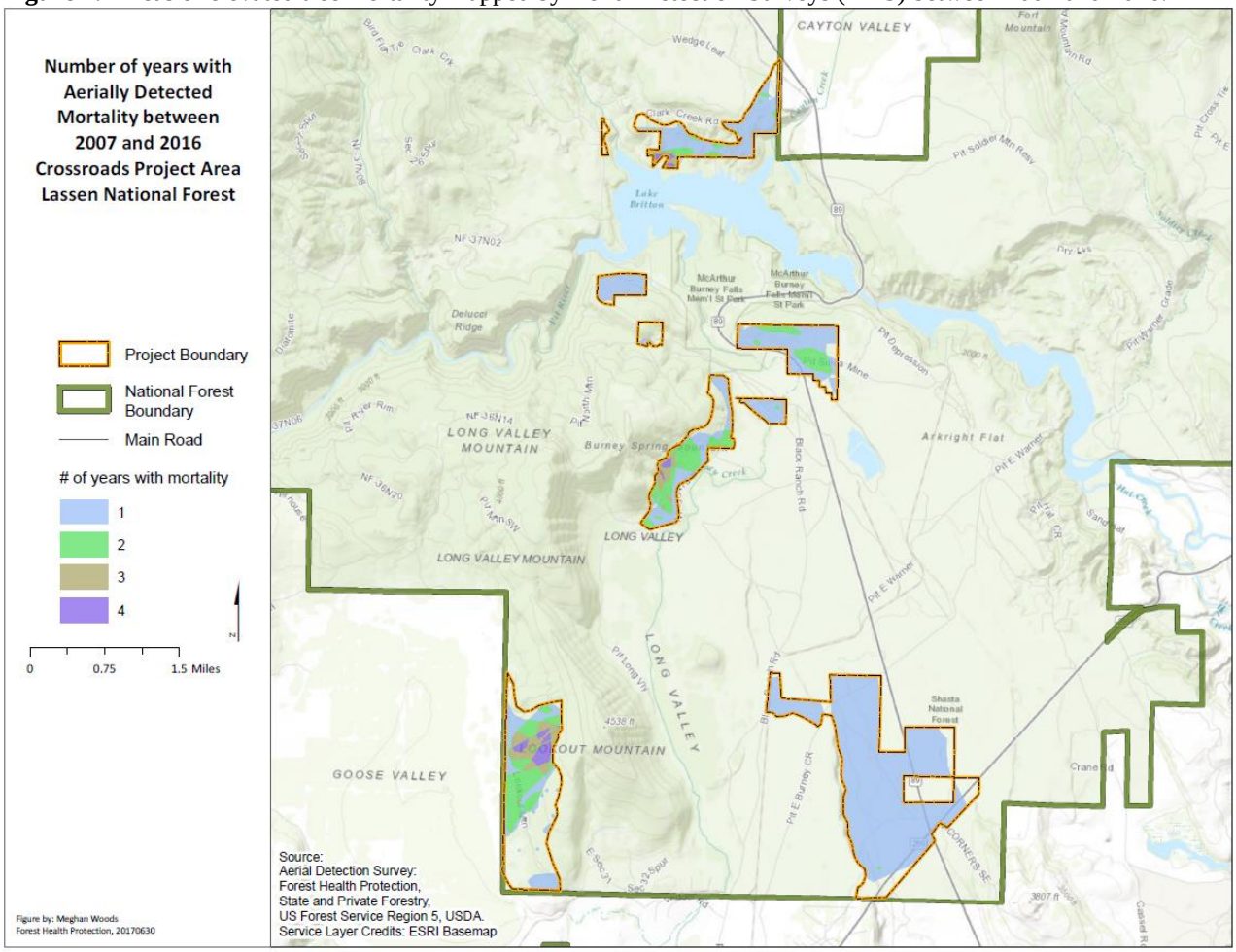
[2] PHDI values ranging from -2.00 to -2.99 are considered moderate drought conditions. Severe drought conditions range from -3.00 to -3.99 and extreme drought conditions are below -4.00.

Predicted climate change is likely to impact trees growing in this area over the next 100 years. Although no Lassen National Forest specific climate change models are available at this time, there is a general consensus among California models that summers will be drier than they are currently. This prediction is based on the forecasted rise in mean minimum and maximum temperatures and remains consistent regardless of future levels of annual precipitation (K. Merriam and H. Safford, *A summary of current trends and probable future trends in climate and climate-driven processes in the Sierra Cascade Province, including the Plumas, Modoc, and Lassen National Forests*). Under this scenario, the risk of bark beetle-caused tree mortality will likely increase for all conifer species, especially drought intolerant white fir and Douglas-fir growing on these low elevation, warmer sites. Improving the resilience of stands to future disturbance events

Figure 2. Scattered ponderosa pine mortality caused by drought, overstocking and western pine beetle.

Figure 3. Scattered ponderosa pine mortality caused by drought, poor growing site and California flatheaded borer.

Figure 4. Areas of elevated tree mortality mapped by Aerial Detection Surveys (ADS) between 2007 and 2016.



through density, size class and species composition management will be critical to maintaining a healthy forested landscape.

Considerations for thinning treatments

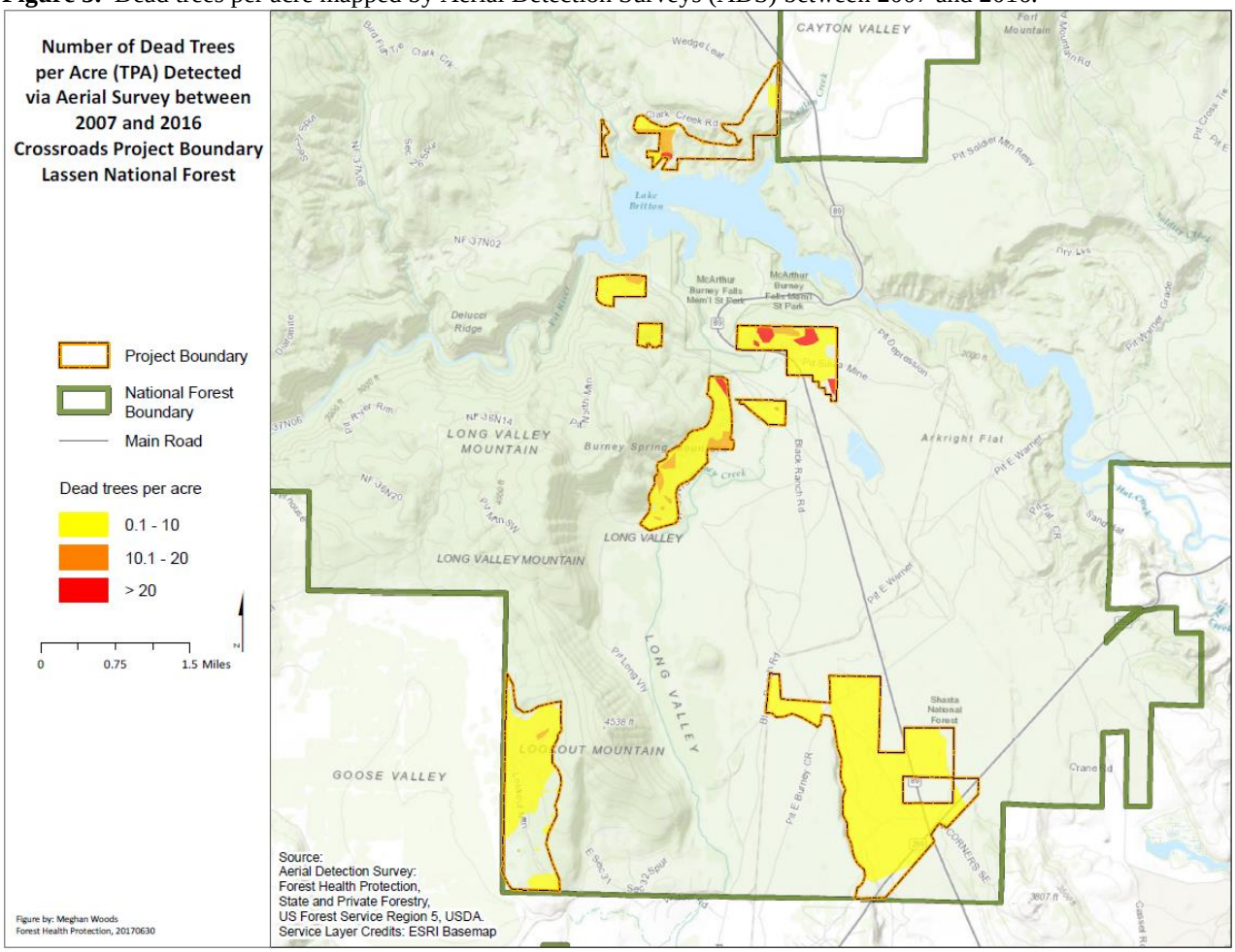
The proposed thinning treatments for the Crossroads project should effectively reduce inter-tree competition for limited water and nutrients and reduce the risk of insect and disease-caused

mortality for most areas. This is consistent with 2014 Farm Bill Section 602(d)(1) direction that allows the implementation of projects "….to reduce the risk or extent of, or increase the resilience to, insect or disease infestation in the areas."

For ponderosa pine stands, the District should consider using the bark beetle limiting SDI of 365 as a basis for thinning prescriptions. SDI 365 is considered the upper management zone above which bark beetle outbreaks are likely to occur and SDI 230 is considered the threshold for the zone of imminent bark beetle caused mortality. Within this zone, endemic populations kill a few trees but net growth is still positive (Oliver 1995). Planning thinning treatments that result in stocking levels well below SDI 230 would greatly reduce the risk of bark beetle-caused mortality in these areas. Mixed conifer stands should be thinned to a relative density of 25 - 40% (relative to the maximum Stand Density Index, or SDI) for a specific conifer species or for a weighted composition of conifer species. This approach will also increase the longevity of treatments as they should stay below 60% relative density, the general threshold for self-thinning, for many years. For the Crossroads project area, the District should consider basing relative density targets on the pine component of most mixed conifer stands. A possible target could be a maximum stand density index of 450 for ponderosa pine as suggested by Long and Shaw 2005.

When planning thinning treatments, it should be recognized that the target stand density is an average to be applied across the landscape and some variability may be desired. Individual high value trees, such as mature pines, and drier areas dominated by ponderosa pine should benefit by

Figure 5. Dead trees per acre mapped by Aerial Detection Surveys (ADS) between 2007 and 2016.



having the stocking around them reduced to lower levels. Allowing for denser tree spacing and pockets of higher canopy cover may be desirable around potential wildlife trees, such as forked and/or broken-topped trees. Incorporating the concepts of GTR 220 will address many of these issues and be consistent with Region 5 ecosystem restoration goals. Many of these methods are also consistent with past Forest Health Protection recommendations for thinning in ponderosa pine and mixed conifer stands and their use is supported for the Crossroads project.

When implementing thinning projects, retaining more drought tolerant pine species over shade intolerant species should be the objective in all units. In addition, when selecting trees for removal, preference should be given to trees heavily infected with dwarf mistletoe, root disease and trees infested with bark beetles.

It is recommended that a registered borate compound be applied to all freshly cut conifer stumps >14" in diameter to reduce the chance of creating new infection centers of *Heterobasidion irregulare* and *H. occidentale* formerly referred to as P-type and S-type annosus root disease, through harvest activity. It is not necessary to treat Douglas-fir stumps as Douglas-fir has a low susceptibility to Heterobasidion root disease.

Potential for funding thought the Western Bark Beetle Program

Forest Health Protection may be able to assist with funding, including NEPA activities, for thinning and removing green material from overstocked areas within the Crossroads project area. Thinning treatments that reduce stand density sufficient to lower the risk to bark beetle-caused mortality would meet the minimum requirements for Western Bark Beetle Program funding and would be supported by this evaluation. If you are interested in this competitive funding please contact me for assistance in developing and submitting a proposal.

If you have any questions regarding this report and/or need additional information please contact Danny Cluck at 530-252-6431.

/s/ Danny Cluck

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cc: Naomi Brown, Acting Timber Management Administrator, Hat Creek RD
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Western Pine Beetle

The western pine beetle, *Dendroctonus brevicomis*, has been intensivly studied and has proven to be an important factor in the ecology and management of ponderosa pine thoughout the range of the host species (Miller and Keen 1960). This insect breeds in the main bole of living ponderosa pine larger than about 8 inches DBH. Normally it breeds in trees weakened by drought, overstocking, root disease, dwarf mistletoe or fire. Adult beetles emerge and attack trees continuously from spring through fall. Depending on the latidude and elevation, there can be from one to four generations per year.

Evidence of Attack

Initial attacks are made about mid-bole and subsequent attacks fill in above and below. Pitch tubes are formed on the tree trunk around the entry holes. Successful pitch tubes are red-brown masses of resin and boring dust. Relativly few, widely scattered white pitch tubes usually indicate that the attacks were not successful and that the tree should survive. Pheremones released during a successful attack attract other conspecifics. Attracted beetles may then spill over into nearby apparently healthy trees and overwhelm the tree with sheer numbers.

Life Stages and Development

These beetles pass thorugh the egg, larval, pupal and adult stages during a life cycle that varies in length dependent primarily on temperature. Adults bore a sinuous gallery pattern in the phloem and the female lays eggs in niches along the sides of the gallery. The larvae are small white grubs that first feed in the phloem then mine into the middle bark where they complete most of their development. Bluestain fungi inoculates the tree during successful attacks, blocking trachids and vessicles which contribute to the rapid tree mortality associated with bark beetle attacks.

Conditions affecting Outbreaks

Outbreaks of western pine beetle have been observed, and surveys made, in pine regions of the Westsince 1899 (Hopkins 1899; cited in Miller and Keen 1960). An insect survey completed in 1917 in northern California indicated that over 25 million board feet of pine timber had been killed by bark beetles.Information from surveys conducted in the 1930's indicated enormous losses attributed to the western pine beetle around that time. During the 1930's outbreak, most of the mortality occurred in stands of mature or overmature trees of poor vigor (Miller and Keen 1960). Group kills do not typically continue to increase in size though successive beetle generation as is typical with Mountain Pine Beetle and Jeffreay Pine Beetle. Rather, observations indicate that emerging beetles tend to leave the group kill area to initiate new attacks elsewhere.

The availability of suitable host material is a key condition influencing western pine beetle outbreaks. In northeastern California, drought stress may be the key condition influencing western pine beetle outbreaks. When healthy trees undergo a sudden and sever moisture stress populations of western pine beetle are likely to increase. Healthy trees ordinarily produce abundant resin, which pitch out attacking beetles, but when deprived of moisture, stressed trees cannot produce sufficient resin to resist the attack. Any condition that results in excessive demand for moisture, such as inter-tree completion, competing vegetation, or protracted drought periods; or any condition that reduces the ability of the roots to supply water to the tree, such as mechanical damage, root disease or soil compaction, can cause moisture stress and increase susceptibility to attack by the western pine beetle. Woodpeckers, predacious beetles, and low temperatures act as natural control agents when beetle populations are low (endemic populations).

Fir engraver beetle

The fir engraver attacks red and white fir in California. Fir engraver adults and developing broods kill true firs by mining the cambium, phloem, and outer sapwood of the bole, thereby girdling the tree. Trees greater that 4" in diameter are attacked and often killed in a single season. Many trees, weakened through successive attacks, die slowly over a period of years. Others may survive attack as evidenced by old spike-topped fir and trees with individual branch mortality. Although many other species of bark beetles cannot develop successful broods without killing the tree, the fir engraver beetle is able to attack and establish broods when only a portion of the cambium area has been killed.

Evidence of Attack

Fir engravers bore entrance holes along the main stem, usually in areas that are > 4" in diameter. Reddish-brown or white boring dust may be seen along the trunk in bark crevices and in spider webs. Some pitch streamers may be indicative of fir engraver attacks; however, true firs are known to stream pitch for various reasons and there is not clear evidence that pitch streamers indicate subsequent tree mortality or successful attack. Resin canals and pockets in the cortex of the bark are part of the trees defense mechanism. Beetle galleries that contact these structures almost always fail to produce larval galleries as the adults invariably abandon the attack. Pitch tubes, often formed when bark beetles attack pine, are not produced on firs.

Adults excavate horizontal galleries that engrave the sapwood; the larval galleries extend at right angles along the grain. Attacks in the crown may girdle branches resulting in individual branch mortality or "flagging". Numerous attacks over part or the entire bole may kill the upper portion of the crown or the entire tree. A healthy tree can recover if sufficient areas of cambium remain and top-killed trees can produce new leaders. The fir engraver is frequently associated with the roundheaded fir borer and the fir flatheaded borer.

Life Stages and Development

In the summer, adults emerge and attack new host trees. The female enters the tree first followed by the male. Eggs are laid in niches on either side of the gallery. Adult beetles carry the brown staining fungi, *Trichosporium symbioticum*, into the tree that causes a yellowish-brown discoloration around the gallery. The larvae mine straight up and down, perpendicular to the egg gallery. Winter is commonly spent in the larval stage, with pupation occurring in early spring. In most locations, the fir engraver completes its life cycle in 1 year; however at higher elevations 2 years may be required.

Conditions Affecting Outbreaks

Fir engravers bore into any member of the host species on which they land but establish successful galleries only in those that have little or no resistance to attack. Populations of less aggressive species like fir engraver are likely to wax and wane in direct relationship to the stresses of their hosts. Drought conditions often result in widespread fir mortality; however, attempting to determine when outbreaks will occur is difficult. Lowered resistance of trees appears to be a contributing factor. Overstocking and the increased presence of fir on sites that were once occupied by pine species may also contribute to higher than normal levels of fir mortality. Several insect predators, parasites and woodpeckers are commonly associated with the fir engraver and may help in control of populations at endemic levels.

Flatheaded Fir Borer

Flatheaded fir borers commonly breed in felled trees or those weakened by fire, defoliation, drought, or other types of disturbance. Trees infested are usually pole size or larger. Beetles can

infest the entire tree or attacks can be confined to the upper crown and result in top kill. Flatheaded fir borers are considered less aggressive in their attacks on living trees than bark beetles. This beetle can be particularly aggressive on Douglas-fir growing on the edge of stands or scattered patches of trees on dry sites.

Detection of flatheaded fir borer attacks prior to the yellowing of the tree's crown is difficult. Unlike bark beetles, there are typically no external indicators of attack such as boring dust or pitch streams on the bark. For this reason, infestations are rarely diagnosed before the damage has already occurred. However, it is sometimes possible to identify infested green trees during the fall and winter months from the patches of bark removed by woodpeckers searching for beetle larvae. By the time the infested tree's foliage turns red, usually in the late spring or early summer in the year after attack, beetles have already left the tree. The only way to confirm a beetle attack is to remove a piece of bark and look for its distinctive gallery pattern. Larvae construct wide, winding galleries that increase in width as larvae grow. Galleries are filled with a brown dust packed in concentric lines. The removal of bark from the tree's lower bole does not guarantee detection of a flatheaded borer attack, since sometimes attacks are confined to the upper crown.

Although called a borer, the larvae of this large beetle feed and develop in the phloem/cambium interface, much like bark beetle larvae, and never bore into the tree's sapwood. The life cycle of the flatheaded fir borer normally requires one year. Adults emerge in the spring and feed on conifer needles before flying to a suitable host tree. Adult beetles can sometimes be seen resting on tree bark exposed to direct sunlight. Eggs are laid in bark crevices and upon hatching; larvae immediately bore into the inner bark. Larvae feed in the inner bark without boring into the sapwood. Late in the summer or early fall, larvae construct pupal cells in the outer bark. Winter is spent in the outer bark and adult beetles emerge the following spring.

***Ips* spp.**

Ips spp. attacks have been recorded on most species of pines in California. These beetles kill saplings, poles and sawtimber up to about 26 inches dbh and the tops of even larger trees. Attacks on live trees are usually limited to trees which are suppressed, or stressed by dwarf mistletoe, root disease, drought, fire or the attack of other insects. If fresh slash is available in the spring, pine engravers may build up in an area and cause localized mortality or top killing by mid-summer.

Attacks are made with the coming of warm weather in the spring. Attacking males bore nuptial chambers in the inner bark and release a pheromone which attracts other beetles to the attack site. If many beetles are attracted, they may attack nearby trees and cause a group kill. Within a day or two of the attack by the male, two to five females enter the nuptial chamber and after mating, each female bores an individual egg gallery which lightly scores the sapwood. The size and pattern of the combined gallery pattern is often diagnostic of the species of Ips involved. The galleries are kept open by beetles pushing boring dust out through the entrance hole. Red boring dust collecting in bark crevices or spider webs is diagnostic of a successful attack. Eggs are laid in niches along the sides of the galleries. Larvae hatch from the eggs and feed in the phloem. They eventually pupate in cells at the end of their larval mines and transform to adults.

A new generation is produced in as little as 6-8 weeks in the spring to 4-6 weeks in mid-summer (August). Thus, several overlapping generations per year may be produced. The winter may be

passed in any of the life stages of larvae, pupae, or adults, depending upon which *Ips* species is involved.

Outbreaks in standing, healthy trees are sporadic and of short duration, and are often associated with some temporary stress or shock afflicting the host species, such as drought or logging disturbance. Tree killing frequently occurs where green pine slash, which serves as breeding habitat is left untreated during spring and summer. To be suitable as *Ips* breeding habitat, pine slash must have bark from 1/8 to 1 inch thick (usually 3 to 26 inches diameter), must have succulent cambium and must remain moderately cool during the development period.

Fresh pine slash caused by thinning, dwarf mistletoe control work, construction or winter storm breakage can be modified in a number of ways to make it unsuitable for *Ips* breeding. One approach to minimizing damage is to schedule slash-generating activities mostly between mid-July and late-December, when the slash has a high probability of drying out, heating up, or spoiling before the beetles can complete their development. Utilization of the cut material to the smallest possible diameter will minimize the amount of breeding material available to *Ips* beetles. If green pine slash must be created during the spring and early summer, slash treatments are available to prevent the buildup of pine engraver populations. Because *Ips* beetles can complete their development in about a month under ideal conditions, treatment should be carried out soon after cutting to be effective.

Slash treatment methods which generally work well include chipping, lopping and scattering slash in sunny areas to heat it up, crushing or mashing slash with logging equipment to make it unsuitable for *Ips* breeding, or piling and burning the slash within a month of cutting. Broadcast burning the slash might work if it could be done without damaging the residual stand. A method which has worked during the summer in hot climates is to pile slash in a sunny area and tightly cover the pile with clear plastic. If the temperature under the bark of slash in all parts of the pile reaches 120^{o}F, all brood currently in the pile will be killed. Lower temperatures will not be effective and, where successful, this method will not prevent reinfestation of slash piles. Because most *Ips* attacks occur within a quarter-mile from the location where the beetles emerged, high value pines can be given some protection by removing fresh pine slash to areas which do not have pines.

Two practices which should generally be avoided are piling fresh pine slash without further treatment, and allowing slash to touch or remain near valuable leave trees.